CAN REPEATED PAINFUL BLUNT IMPACT DETER APPROACH TOWARD A GOAL?

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ABSTRACT

Painful blunt impact from a low-mass, high-speed projectile has been considered as a possible non-lethal weapon for deterring weakly- or moderately-motivated approach toward protected locations. The potential effectiveness of blunt impact as an avoidance motivator or approach deterrent was tested in an experiment in which human volunteers were asked to approach a protected site under both non-threat conditions and paintball repeated-threat conditions. No incentive was offered for completing the approach and shooting task. The motivation for escape or avoidance was manipulated by varying the threat of blunt impact from a paintball at three levels: no threat, a hit from a single gun during each approach, and potentially multiple hits during each approach from a multi-gun array.

Blunt impact compelled only 25% of subjects to escape (i.e. to terminate their participation in further approaches). The threat of blunt impact did not increase avoidance, induce hesitation, nor impair shooting accuracy. Blunt impacts produced varied pain ratings, but pain was not a predictive factor in any escape, avoidance, or performance measure. Subjects who chose not to continue their approach trials did not differ on any measure from those who completed all approach trials under threat. Prior paintball experience did not predict escape likelihood. Probable selection biases suggest that these results best generalize to intrinsically motivated individuals who are not risk-averse and may be familiar with blunt impact pain.

1. INTRODUCTION

Military commanders are often confronted with situations in which an opposing unarmed force, an unpredictable person, or a mob are approaching or occupying a position that places the commander's troops in jeopardy. Under these circumstances, a commander would like to know whether some force can be applied that will elicit a desired response (go away) without producing lasting harm to the targeted individual(s).

The answer to this question may not be simple. The targeted individuals' choice of behavior is likely to depend upon the balance among competing motivations. Motivation is the internal condition that activates or energizes behavior and gives it direction. According to various theories, motivation is rooted in the need to minimize aversive states (physical pain, fear, anxiety, etc) and maximize hedonic states or pleasure. Motivation may be linked to a specific need, such as eating and resting, or a desired object, hobby, goal, state of being, ideal, or it may be attributed to less-apparent reasons such as altruism, morality, or avoiding mortality.

Individuals navigate complex and often conflicting perceptions of consequences resulting from their actions throughout everyday life. The desire to obtain a goal often conflicts with the desire to avoid a punishment associated with that very same goal. Similarly, choices between two outcomes may represent competing rewards or punishments, requiring a continuous assessment of which choice is better (or worse). For instance, a soldier in battle might have to choose between helping a wounded squad member to safety by crossing a field of fire vs. staying in place to remain safe. Or a wounded soldier might have to choose between living with a permanent disability vs. undergoing a risky, painful surgical procedure. In both examples, there is no single, clear source of motivation.

A number of theories have been postulated to explain behavior in these conflicting reward and punishment paradigms. Busemeyer and Townsend (1993) credited the original "approach-avoidance" formulations of motivation offered by Lewin, Hull (1938), and Miller (1944) as one of three critical theoretical cornerstones to contemporary Decision Field Theory. Lewin's work inspired the practice of viewing conflicts as one of three variations, depending on the presence of positive (eliciting approach) and negative (eliciting avoidance) valences. The term approach-avoidance conflict describes one of these conflict situations (Lewin, 1935; 1946). The literature suggests that the mechanisms influencing one's behavior (typically, the perceptions of outcomes/operant contingencies) change, depending on one's proximity to the desired object (or, metaphorically, on how "close" one "moves" toward committing to a choice). Field Theory thus portrays one's environment as a force that pulls and pushes the person to behave in relation to the different situations. It is therefore important to evaluate motivated responses at multiple points along a path of goal-directed behavior. (For more discussion of the relevant theoretical framework for this experimental design, see Short et al., 2010.)

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Blunt impact weapons, such as the MCCM rubber ball munition or the 12-gauge or M203-launched blunt impact rounds, are currently used in the field under conflict situations and continue to be proposed and refined for field use. However, virtually no data about blunt impact deterrence effectiveness can be found in the literature. One prior experiment from our laboratory (Short et al., 2006) used a similar but more complex approach task, but incorporated explicit social and monetary rewards for approach, included more layers of protection for subjects, and shot paintballs without targeting from a greater distance and at lower velocity. This experiment serves an important exploratory and follow-up purpose. It will first assess the effectiveness of greater blunt impact force on deterrence on people who are not rewarded for approaching and in a simple approach task, with more blunt impact hits on subjects. Then it will seek features of (or circumstances surrounding) blunt impacts that relate to any observed deterrence effectiveness. Data that explore the relationship between features of blunt impact force (such as number, impact velocity, painfulness) and probability of deterrence (whether measured as overt escape or slowing of approach) would be valuable in making design and deployment decisions for tools that deliver blunt impact force with the goal of deterrence. The present experiment examined the effects of blunt impact on targeting and approach-avoidance behavior in a paintball task scenario. The task situation was structured on competing, incompatible motivations: the conflict between wanting to succeed at the task and "look good" to the experimenters and oneself, and wanting to avoid or escape the threat of being hit by paintballs. The conflict between motivations is intended to produce some stress, and that stress should generate coping behaviors that include escape or avoidance responses.

2. METHOD

A participant's task in the paintball game was to traverse a distance between a start location and a shooting location. Upon reaching a shooting location, the participant was instructed to hit each of three targets before proceeding to the next shooting location. A subject had to traverse the approach distance for four such shooting locations on an approach trial. Points were awarded for traversing the space between locations and accurately hitting targets and provided a weak extrinsic motivation for continuing the task (i.e. approaching the threat). Arbitrary points accrued were displayed in real time on a monitor that could be seen clearly as the subject moved through course.

Blunt impact deterrence was further assessed by manipulating the level of threat on a trial. Subjects traversed the distance between shooting locations with some probability of being hit by a paintball delivered from different devices. No paintballs would be encountered in Threat Level 0. Paintballs were delivered from a single ATS-AT4 marker by a highly experienced shooter under Threat Level 1, and from a multi-gun flexible array aimed by the same experienced shooter under Threat Level 2. Subjects were aware of the threat contingency on each trial.

2.1 Subjects

Twenty males between the ages of 18 and 52 were recruited from the general public. Every subject completed an informed consent process. Subjects were given instructions on how to participate in the experiment and briefed on proper safety procedures. Unskilled subjects were shown how to properly hold and aim the paintball marker. All subjects were given opportunities to ask questions. Subjects were not restricted in their preferred method of holding the weapon during the experiment. All subjects were given a period of time to practice.

Subjects conducted a baseline run through the course to collect data for each zone without the blunt impact stimulus. Subjects then conducted several runs through the course with single or clustered blunt impacts occurring in every zone (Table 1). Between each run, researchers inspected impact locations and subjects completed assessment tools on perceived pain levels, stress, and motivation.

2.2 Materials

The experiment was conducted in a long narrow approach arena (see Figure 1), in which a subject approached toward the nominal goal, but the goal end held a bench from which paintballs were aimed at the approaching subject (Figure 2). This arena design provided an approach-avoidance scenario in which to test deterrence. Information such as time to approach from one station to the next, number of shots at each station, and latency to leave each station was gathered electronically via a custom LabView program.

2.3 Measures

Our primary outcomes were measures of behavioral escape and avoidance responses in real time. Those responses entailed interruptions in, delay of, or curtailment of approaches toward shooting station goals within approach rounds.

Escape: Termination of a subject's involvement in the experiment constituted an escape response. This binary (yes/no) response was described as a frequency within the sample. Associated continuous variables related to the escape response supplemented the count of escaping vs. non-escaping subjects. Those related or overlapping variables included: latency to the escape response, cumulative number of hits prior to escape response, relative impact velocity of hits immediately prior to escape, and number of hits per approach prior to escape. We recorded

short-term avoidance or escape behaviors such as location at time of escape and delays in approach movement in response to aversive stimuli.

Figure 1: Experimental approach arena, with shooting stations, targets, and marksman's station (threat source) at the far end

Avoidance: Hesitation prior to approach (increased latency after completion of the firing task before beginning approach), or slowed approach toward a goal (increased approach duration), constituted an avoidance response. We evaluated avoidance responses under threat relative to approach behavior toward corresponding shooting station goals during non-threat approach rounds. We measured avoidance responses with pressure-sensitive pads on the floor at each shooting station, in conjunction with records of the latency and number of trigger pulls and the number, location, and timing of target hits. As with escape responses, we recorded avoidance response prevalence along with latency or approach progress at the onset of avoidance responses, cumulative number of hits prior to escape response (reflecting cumulative perception of or valuation of threat), relative impact velocity of hits immediately prior to the avoidance (a component of threat magnitude), and number of hits per approach expected following the avoidance (another component of threat magnitude). Video cameras recorded the paintball sessions for backup analysis. Voluntary termination of involvement constituted an escape response, regardless of the rationale for termination that might be offered at the time.

Subjective pain magnitude scores, recorded immediately following each round of approaches, served as a gross indicator of the subject's evaluation of the blunt impact deterrent motivation during that approach round. The Borg CR-10 scale was used because it is a quick, open-ended but subjectively-anchored pain scale that can reliably be administered repeatedly; and it has been cross-validated with other pain scales. We compared pain evaluations with escape and avoidance responses to ascertain any relationships between the subjective experience and the behavioral responses. Our prior data (Short et al., 2006) suggested that no relation exists between pain evaluation and escape or avoidance behavior, but several models of

blunt impact effectiveness use pain as a key predictive variable. The pain measures obtained allowed some data-driven evaluation of those modeling assumptions.
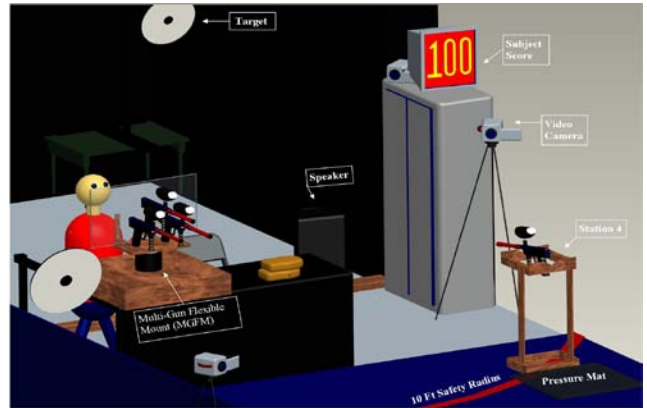

Figure 2: A single marker or an array of three paintball markers mounted on a flexible turret located at the front of the test bed was used to shoot participants as they traversed the distance between shooting locations.

2.4 Procedure

Subjects were recruited from the general population through advertisements posted at shopping areas, colleges, and other public locations. Upon arrival, subjects went through a detailed consent process, including self-exclusions for several health problems that may be exacerbated either by exercise or by blunt impact injuries. Subjects wore jeans or sweatpants, a groin protector, and a thin t-shirt provided by the experimenters, in addition to a face and neck protector. After consenting and administration of initial questionnaires, subjects practiced the approach and shooting task. Participants were assigned to one of the two trial sequences (Table 1), and commenced with the first approach trial. After each approach, the subject returned to the intake area where he completed pain, stress, and motivation questionnaires and was visually examined to document the location of and to characterize the damage from all paintball hits. All hits were also documented photographically. Each subject was reminded of the threat sequence that he would face and was then given the option to return for the next approach trial. When subjects had completed all the approach trials that they chose to complete, they were paid a flat participation fee corresponding to $20/hr for the period that it would typically take subjects to complete all 7 approach trials. Those who quit early did not receive less compensation.

2.5 Task Scenario and Approach Motivation

A participant tried to accrue as many points as possible by approaching a series of four shooting stations in sequence (1 - 4). While at the shooting location, the subject shot his paintball marker at two target locations, alternating

between them until a series of three target hits occurred. The targets were situated toward the end of the arena that he was approaching. Shown in Figure 1 and Figure 2 are the approximate configuration of the arena and the shooting station locations that served as the subjects' intermediate goals.

Trial Number	Blunt Impact Threat Level/Type	Possible Hits
Practice	Level 0: None	0
1	Level 0: None	0
2	Level 1: Single	4
3	Level 1: Single	4
4	Level 0: None	0
5	Level 2: Cluster	12
6	Level 2: Cluster	12
7	Level 0: None	0
1-7	(Total Number)	32

Table 1: Trial sequence for half the subjects, with threat levels and possible hits listed for each trial. For the other half, the cluster threat and the single threat were reversed.

Both targets hit and shooting stations reached earned the player points. Points were awarded for speed of play. Points served only as a visible indicator of progress or accomplishment for the subject. No external reward accompanied high point totals. Individuals were given no reference for comparing their point totals to the totals from other participants, nor to an average or typical point total. The points therefore served as only the most minimal extrinsic motivation factor, appealing instead to whatever intrinsic motivation factors that each subject brought to the experimental setting. Participants chose whether to advance to the next goal square in the sequence and gain points, or halt progress toward goals, either temporarily or permanently. Subjects were not hit while shooting at the targets at a shooting station, but only while they advanced to the next shooting station. Participants traversed each threat zone to accomplish a task: earn more points (and whatever individual satisfaction or expected social reward accrues from that expanding point total) by attaining the next goal location (shooting station) and firing the marker that he found there to hit the three-target sequence.

Subjects repeated the four-goal approach task up to seven times under different threat conditions (Table 1). Three approach trials offered no threat to the subject (Threat Level 0), two approach trials offered the single-gun blunt impact threat (Threat Level 1), and two approach trials offered the 3-gun-turret blunt impact threat (Threat Level 2). The order of presentation of the two non-zero threat levels was counterbalanced across subjects, with subjects randomly assigned to one of the two sequences listed. The three no-threat trials were situated at the beginning, the middle, and the end of participation to allow comparison of performance as a function of experience.

3. RESULTS

Of the 20 subjects who participated in the experiment, 5 subjects chose to terminate their involvement, preventing any further threat approach trials, before completing all trials. Thus, the escape rate for subjects was 25%.

Figure 3 shows the percentage of these individuals who quit during (n=3) or just before (n=2) each of the three threat conditions. Although a greater percentage of subjects quit when faced with Threat Level 1, there are too few observations to come to any strong conclusions about why an individual chose to terminate the experiment. Comments by those subjects as to why they terminated the experiment also were not particularly illuminating. Data for the five subjects who terminated the experiment before completion are either removed from or treated separately from other data in subsequent analyses, as noted in each.
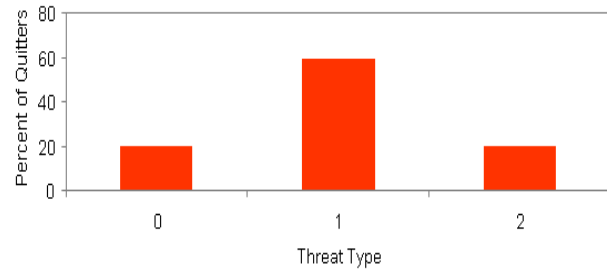

Figure 3: Threat Level during or just before quit time for those who terminated approach.

A reasonable prediction would be that subjects who receive hits at closer range, and therefore at a higher impact velocity, would be more likely to halt their approach. However, distance from the marksman was not a clear predictor of abandoning an approach. Of the three subjects who quit during their approach round (rather than after completing a prior approach round), two quit when at the shooting station farthest down-range, and one quit at the second-closest shooting station to the marksman. No clear conclusions can be drawn from these few events, but even those few observations do not tend to support a hypothesis that quitting is prompted most proximally by higher-velocity blunt-impact projectiles. Four of the five subjects who quit had first completed one or more entire approach rounds under threat, and so had the basis for a clear expectation of the impact velocities encountered and hit probabilities at the closer ranges. It may be that threat of paintball hits is a greater contributor to deterrence than is the most recent blunt impact velocity, but that conclusion would be highly speculative at this point.

On average, each subject received 4.25 paintball hits per completed approach trial across all conditions. For the majority of subjects – those 75% who completed all four threat rounds – this resulted in a total number of 16.9 paintball hits across the duration of the experiment (range:

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12 to 24, SEM ± 0.9). Those who chose to quit received an average of 6.4 total hits (range: 0 to 10, SEM ± 2.0)

The number of hits received during approach rounds was further evaluated according to threat condition and subject escape status. Figure 4 shows mean paintball hits on a subject per approach trial as a function of threat condition and as a function of whether the subjects completed all threat approach rounds. The 3-shot turret paintball gun (Threat Level 2) appeared somewhat more effective (4.7 hits per completed approach) than the single-shot gun (Threat Level 1; 3.6 hits per completed approach) at producing hits on the subject as he moved between targeting locations. However, an analysis of hits under Threat Levels 1 and 2 failed to attain a conventional level of statistical reliability, $F_{(1, 14)} = 3.23$, $p = .09$, for the subjects who completed all approach rounds. No analysis could be completed on those who quit, due to the small numbers in that category.
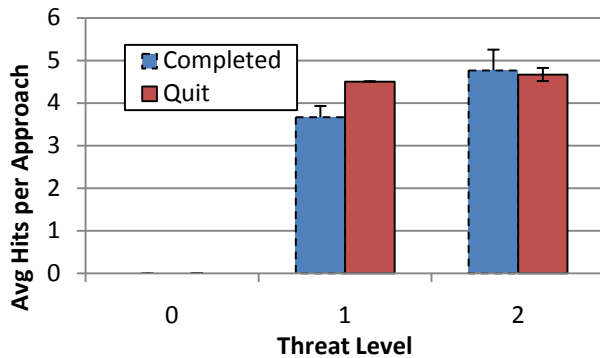

Figure 4: Average number of hits received by each subject during each approach, reported by Threat Condition and by subject response.

On average, subjects assessed the painfulness of all blunt impact hits at about 2.6, which corresponds to a "Moderate Pain" verbal designation on the 0 to 10 anchored portion of the pain rating scale. This rating did not reliably differ between those who quit (mean pain rating = 2.6) and those who chose to complete all approaches (mean pain rating = 2.4). The average subject gave his rating of the maximally painful hit he experienced as about 4.5, which corresponds to a "Strong Pain" or "Heavy Pain" designation on the corresponding verbal scale. This average maximum rating did not reliably differ between those who quit (maximum pain rating = 4.3) and those who completed all approaches (maximum pain rating = 4.5).

Pain ratings were also computed according to threat condition and subject escape. Figure 5 shows the average (top panel) and maximum (lower panel) pain ratings as a function of threat condition. Recall that the pain scale could vary from 0 to infinity, with anchors at 0 (corresponding to no pain sensation at all) and 10 (representing the worst pain

that a person had experienced in his lifetime). Both threat conditions produced moderate pain ratings that did not differ across conditions. Maximum ratings were, of course, higher than mean ratings in each threat condition, but did not reveal any differential pattern. Separate repeated-measures analysis of variance (ANOVA) on data from subjects who completed all approaches yielded no significant effect of threat level on pain ratings. No ANOVA was conducted on data from those subjects who chose to quit; too few data points were collected from these subjects to allow a parallel analysis. There was no difference in pain ratings between those who chose to continue and those who chose to quit, whether analyzed by threat level (1&2) or collapsing across the two non-zero threat levels ($ps > .20$).
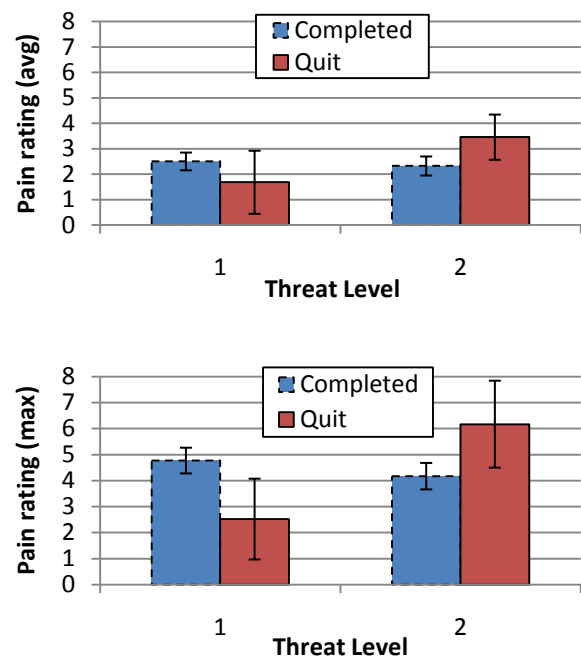

Figure 5: Average (upper panel) and maximum (lower panel) pain reported by subjects who completed all approaches and subjects who quit, for hits taken during Threat Levels 1 (single-gun condition) and 2 (multi-gun array condition).

Recall that it was proposed that increased time to approach or traverse toward the next shooter station might be indicative of avoidance of the approach goal where the marksman is posing a threat. We therefore looked for increased traverse latencies under the two non-zero threat conditions. Figure 6 shows the mean time to traverse the distance from the starting point on a trial to each of 4 shooting locations. Surprisingly, traverse time apparently decreased slightly and similarly under threat conditions 1 and 2 relative to the no-threat condition (Threat Level 0). Subjects were generally faster to traverse the distance to the first shooter station. Inspection of videotapes of individual performance suggested that there is no special significance of this effect with respect to blunt impact or

threat: The starting position for the first targeting position was simply less cluttered and gave subjects the opportunity to begin the trial in a "runner's stance."

A two-factor repeated-measures ANOVA (Threat Condition x Target Location) yielded a significant main effect of target location, $F_{(3, 42)} = 9.51$, $p < .001$. Bonferroni's analysis ($\alpha = .05$) of grand mean traverse times at each target location indicated that subjects were faster to reach target 1 relative to all other positions, which did not differ from one another. The apparent decrease in traverse times toward all shooting stations while under paintball threat (Levels 1 & 2 compared with Level 0) did not reach the customary criterion for reliability (effect of threat level: $F_{(2, 28)} = 2.67$, $p < .08$). There was no interaction between variables.
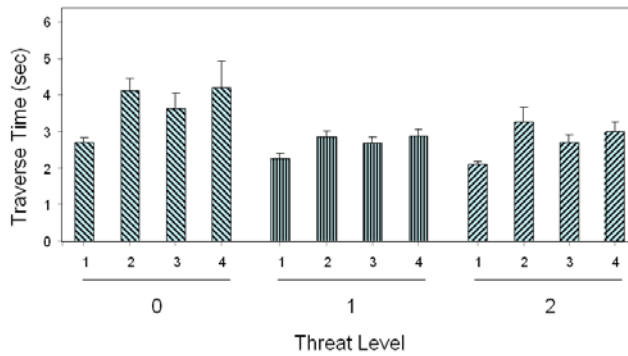
Figure 6: Mean time to traverse the approach distance between each of four shooting locations as a function of Threat Level in place during the traverse.

Figure 7 shows Linger Time, i.e. the time to replace the paintball gun in the holder and to leave the shooting station mat after firing the last round at a target. The "Linger Time" behavioral measure captures and quantifies the safe moments, after task completion but before embarking on the next approach traverse that will expose the subject again to blunt impact threats. Linger Time might be expected to represent the deterrent effectiveness of a force or strategy, as subjects might hesitate to continue their approach toward a goal in the presence of a potentially deterrent force (Threat Levels 1 & 2) compared to their approach in the absence of any deterrent force (Threat Level 0). Linger Time is presented as a function of shooting station location (1, 2, or 3) within each Threat Level for all those subjects who completed all threat trials. It might be expected that subjects would linger at a station longer before initiating a trial as threat level increased, either from no threat to Level 1 or 2, or from the single-gun threat (Level 1) to the 3-gun threat (Level 2). However, a two-factor repeated-measure ANOVA (Target Location x Threat Level) yielded no significant main effects or interaction. Furthermore, subjects who completed all approaches did not differ in Linger Time from those who quit.
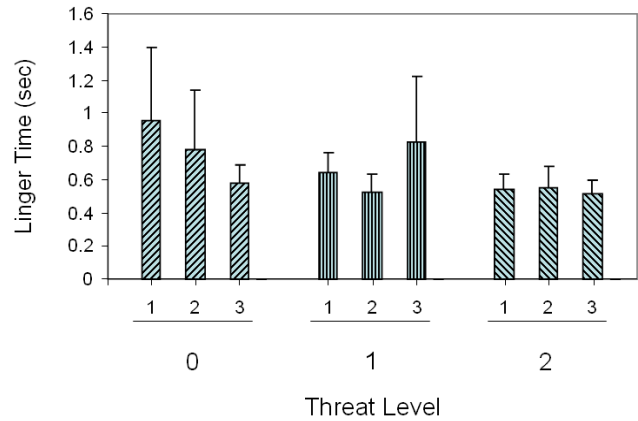
Figure 7: Linger Time at the first 3 shooting locations as a function of threat level for subjects completing all approach rounds.

Neither target number nor threat level had any influence on Shooting Accuracy as indicated by either measure. Separate two-factor repeated measures ANOVAs (Target Number X Threat Level) on number of shots and time to hit the target yielded no reliable main effects or interaction (all $ps > .20$). The figure represents data only from those subjects who completed all approach rounds; however, no reliable difference between those who completed all approaches and those who escaped prior to completion was observed on either measure of Shooting Accuracy.

The scatter plots in Figure 8 show the distribution of mean traverse time for each individual under threat conditions 1 & 2 compared with their corresponding maximum pain rating for that threat condition. The plots differentiate between those subjects who completed all four threat rounds and those who quit after only partial exposure to the threats. If a single, salient painful blunt impact is modifying approach behavior, then we might expect that maximum pain would be correlated strongly and reliably with traverse time. Correlational analyses were attempted between maximum pain rating and mean traverse time for each subset of subjects and for each threat level. Too few subjects chose to escape the threats to provide sufficient data to allow meaningful correlational analyses within that subject subset. If pain were a reliable or powerful deterrent under either threat condition and if traverse time is an indicator of net approach motivation, then we would expect a strong and statistically significant correlation between these two variables. To the contrary, the correlations between maximum pain and traverse time under Threat Level 1 ($r = 0.29$) and Threat Level 2 ($r = 0.02$) were weak and not statistically reliable, with maximum pain rating accounting for no more than 8% of the variation in traverse times under either type of threat.
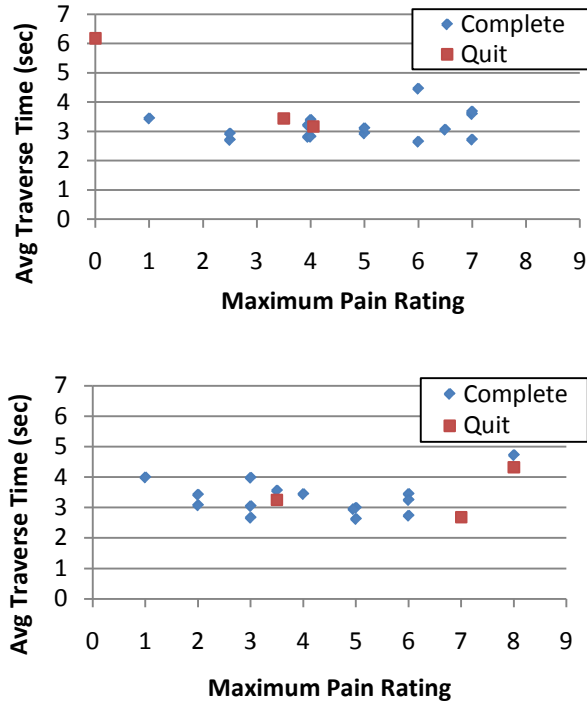
Figure 8: Scatter plots relating average traverse time to maximum pain rating for Threat Level 1 (top panel) and Threat Level 2 (bottom panel) for each subject.

Perhaps the overall pain experience, rather than a single memorable impact, might serve to deter approach. An analysis of the average pain scores, rather than maximum, compared with mean traverse times for each subject revealed no difference in the pattern. Again, the correlation between variables was weak (Threat Level 1: $r = 0.257$; Threat Level 2: $r = 0.14$) and not statistically reliable. Pain accounted for a very small and inconsistent segment (2% to 6%) of the variance in traverse times among those who completed all approach rounds. Again, no reliable comparison could be made for pain-by-traversal distributions between the subjects who completed all approach trials and those who chose to escape further threats.

4. DISCUSSION AND CONCLUSIONS

The present experiment set out to examine the ability of blunt impact from paintball strikes to serve as a deterrent against a weakly motivated approach in a paintball approach task. The threat of blunt impact did not increase avoidance or impair shooting accuracy. The time to traverse the distance between shooting locations actually decreased as the threat of blunt impact increased. Blunt impact did substantially increase pain ratings; however, pain was not a factor in any task performance measure. Thus, the present experiment provides little evidence that blunt impact from a paintball strike typically deters a

nominally weakly motivated approach response nor impairs shooting accuracy.

Subject selection factors doubtless affected the results: 75% of the recruited subjects had prior paintball gaming experience. These individuals arguably tended to be highly competitive, more aggressive, and more accustomed to the pain of a paintball hit. As a result of the greater competitiveness of the sample, the nominally worthless points awarded for performance in the paintball game may have held higher intrinsic value for these subjects than is typical of less paintball-experienced persons. Moreover, blunt impact from a paintball hit did not appear to be much of a threat to this subject sample – it may have elicited a competitive eustress response instead of a distress response. The faster traverse times as threat level increased may be explainable as a reversal in approach-avoidance motivation from what was intended, due to the more experienced subject sample. Alternatively, the tendency to avoid getting closer to a bigger threat may have been eclipsed by the very rational tendency to reduce exposure time to the threat by running faster. If the goal of this study is to characterize blunt impact deterrence value in the general population, then that sampling bias may be a serious issue. If the results are to be generalized to predict the behavior of other aggressive, highly competitive persons who are accustomed to experiencing blunt impact pain and who probably prove the greatest threat to protected facilities or military or police positions, then the sampling bias of this study is not an issue.

Paintball experience per se may not be the most relevant variable in this sample. It may just be an indicator of subjects who are not risk-averse and may be more competitive – as were, arguably, all subjects who would agree to participate in a painful blunt impact study. We initially suspected that the 25% of participants who terminated the experiment prior to completing all tasks would not be experienced paintball players. This possibility turned out not to be true. Of the five individuals who quit, three had prior paintball experience.

No consistent theme emerged as to why an individual terminated the experiment, and the sample of threat-escapers is too small to come to any strong conclusions in this regard. Even the apparently larger number of subjects quitting during Threat Level 1 (3, or 60% of the quitters) relative to Threat Level 2 (1 or 20% of the quitters) is open to interpretation. Did they quit because of the hits just received under Threat Level 1? Or did they quit in anticipation of the upcoming threat of greater numbers of hits on each approach traverse under Threat Level 2? It is interesting to note that only one subject quit after experiencing Threat Level 1 (just before Threat Level 2), while three subjects quit after experiencing Threat Level 2 and just before or at the beginning or Threat Level 1. It may be argued that Threat Level 2 may not be more

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aversive than Threat Level 1, as intended. Certainly the pain scores did not differ between the two non-zero threat levels, although there was a higher number of hits received on average under Threat Level 2. In fact, two factors associated with Threat Level appear to confound interpretation of aversiveness: The single shots of Threat Level 1 found their targets more reliably than did the multiple-paintball shots of Threat Level 2. The possibility is therefore raised that the higher probability of receiving a hit on an approach traverse by a single shot outweighed the aversiveness of potentially receiving three hits on an approach traverse rather than one. This may still be the case despite the larger number of hits sustained by subjects during the Level 2 threat approach trials.

The results suggest that approach deterrence may not be easy to achieve using pain-mediated blunt impact projectiles against a task-engaged, probably intrinsically-motivated individual. However, another study (Short et al, 2009) with similar recruitment methods found paintball hits to be highly effective at motivating rock-throwers to leave a roadside area and cease or diminish their motivated attack. Several differences emerge that could potentially explain the differences. Subjects in the rock-throwing study, while motivated by greater incentive to stay than this study, did not engage in an explicit approach toward an emplaced threat. Furthermore, escape responses in that study could be made on a trial-by-trial basis, rather than having escape require complete termination of further involvement – "quitting" – as in this study. Further study with paintball blunt impact should be conducted to elucidate the situations and factors, including subject factors, that result in the high effectiveness in some cases and the low effectiveness reported here.

The results from the current experiment do not clearly reveal correlates of deterrence for high-speed elastic blunt-impact collisions. Nevertheless, the experiment clearly outlines a design in which the effectiveness of blunt impact as a deterrent can be assessed under competing motivational circumstances. Although the individuals who chose to participate in the experiment tended not to be deterred by current levels of threat, there is likely to be some level of blunt impact threat that does alter their approach behavior. There is no indication, however, that the deterrent value will be related to the *painfulness* of the impact. Pain associated with paintball hits did not predict any aspect of deterrent effectiveness, either in terms of

escape or avoidance behaviors. If painfulness is indeed related to blunt impact effectiveness at some level, the level of pain would have to be increased substantially, at which point the blunt impact projectiles may become permanently injurious or deadly and therefore less useful as a deterrent tool in non-lethal force application situation. So far, no studies have shown blunt impact pain to be related to deterrence in an approach scenario. Instead of relying on pain and reducing approach motivation, effective blunt impact force for approach deterrence may have to rely instead on physically counteracting the approach with sufficient momentum to knock down the approaching individual. The question remains: What type and level of blunt impact force is required to control these individuals? The current experiment provides a paradigm in which to answer that question.

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